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THE STUDY OF CRYSTALS.

(1) *Crystallography and Practical Crystal Measurement.* By Dr. A. E. H. Tutton, F.R.S. Pp. xiv+946, with 3 plates and 720 figures in the text. (London: Macmillan and Co., Ltd., 1911.) Price 30*s*. net.

(2) *Crystals.* By Dr. A. E. H. Tutton, F.R.S. Pp. x+301, with 24 plates and 120 figures in the text. (London: Kegan Paul, Trench, Trübner and Co., Ltd., 1911.) Price 5*s*. (The International Scientific Series.)

THE rapid advances which have been made in recent years in our knowledge of crystals, and the increasing number of points at which crystallography comes into contact both with chemistry and physics, render it more than ever desirable that students of these sciences should acquire a sound knowledge of the nature and properties of crystals and an acquaintance with the methods of crystallographic research. In illustration of this it is only necessary to refer on one hand to the work of Pope and Barlow on the relation between valency and crystalline structure, and on the other to that of Lehmann, Vorländer, and others on the remarkable group of bodies forming the so-called "liquid crystals."

Although numerous excellent treatises on crystallography have been published in recent years in Germany and France, in England the number of works devoted to this subject has been very limited, and, until the recent appearance in America of a translation of the optical section of Prof. Groth's well-known book, the only information available on the physical side in English has been that contained in the introductory portions of text-books of mineralogy. There was thus ample room for a new book, and Dr. Tutton's volume on "Crystallography and Practical Crystal Measurement" (1) will be welcomed by all workers in the subject. Although in some respects incomplete, its very full treatment of what are, from the practical point of view, the most important branches, viz. crystal measurement and optics, render it a valuable and important addition to the literature.

The book is essentially a practical one, and is chiefly concerned with the methods of determining the form of crystals and of measuring their various physical constants; but attention is also given to the underlying matters of theory. It is divided into two parts of nearly equal length, dealing respectively with the morphology and the physical properties of crystals.

The practical and theoretical portions of the subject are treated side by side, in successive chapters. Thus, in part i., after a short introduction on the nature of crystals, a description of the method of preparing suitable crystals for measurement is followed by a chapter on the goniometer, and this is at once illustrated by an account of the actual measurement of a crystal of potassium sulphate. The succeeding chapters treat of axes and the law of rationality, zones and the stereographic projection, and the formulæ required in calculation; and the measurements of the crystal previously made are then worked out in detail. An account is next given of the theories of crystals as homogeneous structures, and of crystal symmetry and its thirty-two types. Chapters xi. to xxiv. are devoted to an account of the crystal systems and the various forms possible in each of the thirty-two classes, the discussion of each system being followed by a full account of the measurement and calculation of one or two crystals belonging to it.

Among subjects dealt with in later chapters may be mentioned goniometry at higher temperatures and the change in the angles of crystals on heating, goniometers with two and three circles and the gnomonic projection, the density, volume, and structure of crystals and the calculation of their molecular "distance ratios." Part i. ends with a useful account of Fedorov's theory of cubic and hypohexagonal types, and a short reference to the theory of Pope and Barlow on valency-volumes.

The description of Fedorov's theory and his method of arriving at the correct mode of setting up a crystal in accordance with its structure, is especially noteworthy as containing the first account which has appeared in English of his method of "crystallo-chemical analysis," by means of which it will be possible to identify, after measurement of its crystals and reference to an index, any chemical substance of which the crystalline data have been incorporated in the index. The method is not yet available for general use, but in the hands of Prof. Fedorov it has already proved very successful under numerous tests, and seems likely in the future to prove of great service to the chemist.

In the chapters on crystal axes, zones, and indices, as well as in those on crystalline symmetry, the stereographic projection, &c., proofs have perhaps wisely been omitted; but some explanation of the meaning of the numbers forming a zone-symbol might well have been included.

The second, or physical part of the book (pp. 547–933) is devoted almost entirely to the discussion of the optical properties of crystals and the methods of determining them. The methods of measuring the expansion of crystals by heat and their elastic properties by means of the author's interference-apparatus, are also described, and the last chapter contains a short account of the hardness of crystals, and of liquid crystals, and the use of the "crystallisation microscope." No reference is made, however, to other physical properties, such as pyro-, piezo- and thermo-electricity, and thermal and electric conductivity.

The first eight chapters in this part (pp. 545–680) are occupied with a discussion of the nature of light and the mode of its transmission through crystalline media, while the rest of the optical portion (pp. 681–883) is chiefly devoted to a description of the instruments and operations required for the measurement of the various properties expressible by the form and orientation of the optical ellipsoid. This portion includes detailed directions for the cutting and grinding of prisms and plates, the production of monochromatic light of any desired wave-length, the determination

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of the directions of light-vibration in crystal plates, and of refractive indices by means of prisms and by total reflection, and the examination and measurement of interference-figures. Pleochroism and the rotation of the plane of polarisation are also discussed, and there are excellent chapters on the crystallographic microscope and its accessories, with an account of Fedorov's universal stage and the methods due to him and to Becke for the location of the optic axes in a crystal section.

The descriptions are very full, and for the most part clear, but some few points have been noted which seem to call for criticism. Thus, for instance, on p. 585, the mode of construction of the optical ellipsoids on three rectangular axes the lengths of which are made (either directly or inversely) proportional to the values of the refractive indices of the crystal for the vibrations taking place along them, is not made clear at the start; and, moreover, the expression, "the refractive index along" a given direction, which frequently occurs, is ambiguous, and does not seem to be anywhere defined. A slip is noticeable on p. 572, where the wave-front in a crystal is stated in the general case to be an ellipsoid.

The methods and apparatus described throughout the book are principally those of which the author has had personal experience in his well-known researches, and the examples are mostly taken from the same source. The treatment is very detailed and almost unnecessarily circumstantial, and in many places there is a good deal of repetition. Thus, for example, in the seven chapters dealing with crystal calculation, though it is no doubt desirable that the advantage of systematic methods of computation should be impressed upon the student, it was perhaps scarcely necessary to insert the actual working (with a diagram) of every spherical triangle and anharmonic ratio computed; whilst in the physical portion of the book a considerable amount of space might have been saved by the omission of much of the large mass of practical detail, particularly that concerning some of the less readily determinable properties, such as elasticity (of which the account occupies eight pages) and thermal expansion (twenty pages), for which the reader may fairly be expected to consult the original memoirs. A reduction in the size and cost of the book would have been advantageous, as rendering it more accessible and at the same time more useful to the student, who may be apt to be somewhat bewildered by the amount of information provided for him.

The numerous illustrations, which have been mostly drawn by the author or specially engraved for the book, are, with a single exception (Fig. 440), all excellent.

(2) The smaller book is based on a lecture delivered by the author at the meeting of the British Association in Winnipeg in 1909, and is intended for the general reader, to whom it aims at presenting an account of some of the more important properties of crystals—geometrical, physical, and chemical—especially in relation to their molecular structure.

The task of conveying to a reader a clear idea of this somewhat extensive subject within the compass of some 300 pages, without assuming some previous acquaintance with crystals, is no easy one, and the difficulty has been increased by the inclusion of numerous practical experimental details, which, however appropriate in a lecture, are of little use in a book of this kind. In the same way, a very large amount of space (twenty pages) has been devoted to the behaviour of plates of quartz and amethyst in polarised light, some of which might probably have been better utilised for an expansion of other parts of the book which have suffered from undue compression, such as the discussions of interference and of molecular "distance-ratios."

Not a few incorrect or misleading statements have been noticed. Thus, for example, the types of symmetry unrepresented among Sohncke's sixty-five point-systems are not those having no plane of symmetry, as indicated on p. 117, but chiefly those showing hemimorphic character. In chapter v., which deals with crystal-axes and the law of rational indices, the meaning of the axial lengths and the manner in which they are determined by means of the intercepts made by a parametral face are not explained early enough, or with sufficient prominence, and the figures of simple pinacoid forms, with inscribed axes, which illustrate the axes of the various systems, are misleading as to this point. Again, on p. 51, the letters *a, b, c,* are used to denote the three crystal axes, while on p. 57 (without further explanation) they are used for the unit lengths along these axes. Similarly, on p. 57, the "three numbers [*m, n, r*] expressing the intercepts" appear to denote the actual lengths of the intercepts, while at the bottom of the following page the intercepts are explained as meaning the multiples of the unit lengths, *a, b, c.* The meaning of the example on p. 58 is far from clear.

There are numerous admirable illustrations of growing crystals, and a good coloured plate of crystals in polarised light, which have been reproduced from the author's own photographs.

It is to be feared that the book will scarcely be intelligible to a general reader without some previous knowledge of the subject, but the student who is already familiar with the elements of crystallography may find much in it that is interesting and suggestive.

H. L. B.

THE GEOGRAPHICAL BASIS OF HISTORY.

A Historical Geography of the British Colonies. Vol. v., Canada. Part iii., Geographical. By J. D. Rogers. Pp. viii+302. Vol. v., part iv., Newfoundland. By J. D. Rogers. Pp. xii+274. (Oxford: The Clarendon Press, 1911.) Price 4*s.* 6*d.* each vol.

TWO more volumes of Sir Charles Lucas's valuable "Historical Geography of the British Colonies" have appeared, in which Canada and Newfoundland are described. The Canadian volume deals with the geography, but the historical aspect is still largely to the fore. No general account of the whole region occurs, in which the principal characteristics of this portion of the North American continent is given, but we are introduced at once to the far north land and

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